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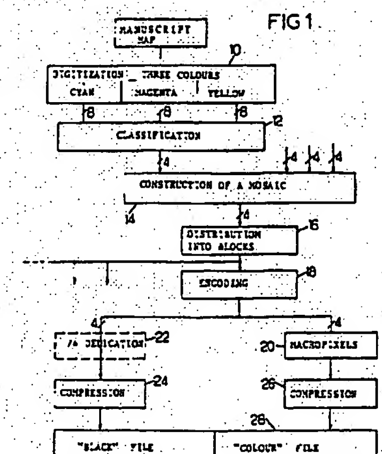
(54) Method and device for the acquisition and digital storage of coloured geographical maps and display of the maps.

(57) A method and a device for digitally storing coloured maps comprises, after digitization as pixels and classification: forming a mosaic of mutually connected maps by re-sampling said maps, in a common reference grid, typically by assigning to each re-sampled pixel the code of the closest pixel obtained by classifying the pixels of each of said maps; splitting up the mosaic into mutually identical blocks, each having a predetermined number of pixels; forming a colour file for each pixel by (e1) compressing the pixels into macropixels each consisting of n mutually adjacent pixels (for example n = 4 pixels; disposed in a square array) and assigning each macropixel to a single class representative code, then (e2) storing, in each line of macropixels, each segment having constant colour segment in the form of the code of the class of the first macropixel of the segment and the number of macropixels of the segment; and forming a black-and-white file for each block by storing, for each line in the block, each black segment in the form of the indication of the first black pixel and the number of pixels of the segment.

FIG 1



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Method and device for the acquisition and digital storage of coloured geographical maps and display of the maps

The invention relates to the acquisition and digital storage of coloured geographical maps and retrieval thereof.

Conventional geographical maps on paper are ill-suited to numerous needs which are increasing at the present time, for example the preparation of long distance missions: each manuscript map can only represent a very limited area, all the more reduced when the map is on a larger scale. The discontinuities represented by the frontiers between maps hinder the preparation of an overall plan.

In theory, nothing opposes acquisition and digital storage of geographical maps on paper: it is sufficient to capture and digitize images as pixels with a scanner. Such a storage is faced with the problem of the volume of data of be stored and, in addition, it does not solve the problem of passing from one map to an adjacent map.

Numerous processors for automatically converting maps into computer- storable form have already been suggested. Reference may for instance be made to the paper by P.J. Min "Computer-aided mapping technology for geographic data base", Proceedings of the S.I.D., Vol. 14, No. 1, 973, pp. 18-25, which describes a vectorial approach for converting map manuscripts into a form which is computer-readable and makes it possible to creating hard copy map outputs. Another approach, which involves a full analysis for feature extraction and consequently requires a very complex system, is disclosed in the paper by R. L. Stanford et al "The application of knowledge base and digital image analysis techniques to automated map interpretation", Proceedings of SPIE, Applications of Artificial Intelligence VI, Orlando, Florida, April 4-6, 1988, Vol. 937, pp. 402-410, SPIE, 1988, Washington U.S.

The prior art methods have one or more of the following shortcomings: they require a complex computing device; the volume of data to be stored for a proper recovery of a colour map is very high; there is no easy possibility to display portions of the map with more than one predetermined definition.

It is an object of the invention to provide a method of acquisition and digital storage of geographical maps which very considerably reduces the volume of data and improves flexibility in use. It is another object to store it under a form which avoids discontinuities comparable to those met with when passing from one paper map to another when displaying portions of two adjacent maps on a same display unit. It is still another object to render it possible to display a portion of a map with a resolution which may be selected between two values, as regards the most significant features.

For that purpose, the invention uses the fact that the resolution required for the coloured pixels (the number of colours used in a map being generally small and not exceeding 8) is much lower than that which is desirable for black indications (level lines, alpha-numeric indications, references,...) and that degradation of the colours is not very troublesome.

The invention consequently provides a method in which:

(a) each of a plurality of mutually adjacent maps is digitized by raster scanning for representing it by a matrix of pixels encoded for representing at least three fundamental colours of each pixel;

(b) the pixels of each of said maps are classified by assigning them to a predetermined number of classes depending on their colour, whereby each of said pixels is defined by a code having a number of bits less than that for step (a);

(c) a mosaic of mutually connected maps is formed by re-sampling said maps, in a common reference grid, typically by assigning to each re-sampled pixel the code of the closest pixel obtained by operation (b);

(d) the mosaic is split up into mutually identical blocks, each having a predetermined number of pixels;

(e) a colour file is formed for each pixel by (e1) compressing the pixels into macropixels each consisting of n mutually adjacent pixels (for example n = 4 pixels disposed in a square array) and assigning each macropixel to a single class representative code, then (e2) storing, in each line of macropixels, each segment having constant colour segment in the form of the code of the class of the first macropixel of the segment and the number of macropixels of the segment; and

(f) a black and white file is formed for each block by storing, for each line in the block, each black segment in the form of the indication of the first black pixel and the number of pixels of the segment.

The invention will be better understood from the following description of a particular embodiment, given by way of example. The description refers to the accompanying drawings, in which:

Figure 1 is a simplified logic diagram of the acquisition storage method;

Figure 1A indicates how each pixel is represented in two files following compression;

Figure 2, complementary to Figure 1, is a logic diagram of the retrieval process for display with a minimum resolution;

Figures 2A and 2B are representations of decompresion sequences;

Figure 3 is a simplified diagram showing hardware components for retrieval and display on the screen.

A method according to the invention comprises several steps, some of which are known, and for this reason will not be described in detail.

1. In the case of acquisition from a paper map, the first step (designated by 10 in Figure 1) consists in digitization so as to generate, from a coloured map, at least three files corresponding to the three base colours. A scanner may in particular be used which, in three passes, provides three files obtained by raster scan, formed of evenly distributed pixels distributed in parallel lines. A spacing between lines and between the pixels of the same line of 0.1 mm will generally be satisfactory for later display. The three basic colours will generally be those used for television, namely cyan, magenta and yellow. It is possible to provide an additional scan for forming a file distinguishing the pixels having a reflectivity or brightness less than a predetermined threshold, considered as "black", from all others. This is however unnecessary, since the "black" pixels may be identified and included in a specific class during the encoding step, through software processing, as will be seen later.

At the end of this step, each of the maps to be stored is available in the form of three files in which a number is assigned to each pixel. The number may be a 8-bit binary number representing a radiometric value (reflectivity for example) for the colour considered.

2. A first encoding consists in a classification (12 in Figure 1) which reduces the volume of data to be stored. The classification may be made in two phases, first of all a "signature computation", then an encoding step properly speaking which makes use of a maximum likelihood classification algorithm.

Computation of the signatures is made by determining optimum class frontiers. It begins by computing a three-dimensional histogram of the three basic colours, over the whole map. The frontiers between classes may then be determined by segmentation of the histogram to define classes best suited to the nature of the original individual maps (which depends on the nature of the ground represented and the mode of representation).

The histogram may typically be divided into segments by the migrating means algorithm, which is an iterative algorithm for causing the class frontiers to adjust progressively in response to the distribution of the pixels.

Such segmentation may be carried out by a software process, with existing programs. Examples of such programs, which are commercially available, include Pace, available from PCI, Inc., Richmond Hill, Ontario, Canada and which is described for instance in "Pace multispectral analysis manual, 1988" and "Pace geometric correction manual", 1988 published by PCI, Inc.

The number of classes is generally defined a priori. It is desirable not to exceed sixteen classes, so as to be able to define each pixel by a number of four bits. For relatively homogeneous maps, eight or ten classes may be sufficient.

It is desirable to check that the selected classes provide a satisfactory visual impression upon display. Interactive learning may be provided. It may consist in selecting a reference image portion, or "picturette", for example of 512 x 512 pixels, selected in a representative map. The portion is chosen so as to contain examples of all graphic data and all colours. The reference portion is encoded, stored and displayed on a CRT and the operator compares it with the original picture. He may then modify the signatures for removing defects, for example formed by dedications which give a subjective impression which is judged unsatisfactory. Signature modification may be made by adjusting the mean value.

Encoding properly speaking uses distribution of the pixels among the classes (some pixels do not correspond to any class, or on the contrary, are included in several classes so that an assignment selection should be made). A maximum likelihood classification may be used of the kind described for example in Duda and Hart, "Pattern classification and scene analysis", Wiley & Sons, 1979, Ch. II. Different clustering methods can be used; for example the class limits are defined by a predetermined deviation for each of the base colours with respect to a mean value for each class (parallelepipede classification).

Classes may be used corresponding to:

white
light grey
dark grey
black
red
green

blue
yellow
. . . .
with a particular code, from 0 to 15 for instance, assigned to each class.

The above step is sufficient when the individual maps to be assembled together are homogeneous, i.e. have comparable reflectivity contrasts and have colours whose shade hardly varies from one map to the other. This favorable situation is met with when the maps belong to the same manufacturing batch.

In other cases, it is not possible to obtain satisfactory results with a small number of classes. It may then be necessary, even for maps having only few colours, to make a distribution among a higher number of classes.

The classes are defined by the operator: first, he monitors, possibly off-line, all the individual maps to be assembled into a mosaic and determines by trial and error what number of classes (and which class signatures give best results on the selected reference portions).

3. Assembling individual maps into a map "mosaic" renders it possible to solve the problem associated with overlapping of mutually adjacent maps and also with the fact that the individual maps are sampled regularly over their own surface, and not in a projection common to all the individual maps to be assembled together.

Assembling into a mosaic 14 consists in resampling the individual maps in a common geographical projection, which may be that of one of the maps. It involves:

- acquiring the characteristic points from each of the elementary maps coded by classification, these characteristic points being possibly those of a goemetric grid;
- computing the coordinates of such characteristic points in a mosaic map resulting from the assembly of the individual maps and deriving therefrom deformation operators, using for example a polynomial regression process of low degree (always less then 6); such step may be implemented using the above-identified programs;
- re-sampling each of the individual maps so as to have, in each map, pixels which are evenly distributed in the common projection.

Re-sampling may be very simple; it may use the algorithm of the closest neighbouring pixel, which consists in assigning each pixel of the common projection to the class of the closest pixel in the original individual map (or in one of the individual maps if there is overlapping).

The amount of deformation undergone during such assembling is always sufficiently small for the size of the pixel not to be significantly modified.

4. For easier display during retrieval, it is convenient to fractionate the mosaic map into "blocks" each corresponding to a fraction only of an individual map and only occupying a fraction of a standard display screen such as a colour TV tube. Cutting up (as indicated at 16) into blocks of 512 x 512 pixels generally gives satisfactory results.

5. For making it possible to obtain a resolution for the linear features and alphanumeric inscriptions overprinted on the map which is better than for coloured areas, where a lower resolution is acceptable, encoding 18 differs from prior art approaches.

Each block is represented by an intermediate "black" file with a resolution corresponding to the size of one pixel (0.1 mm for example) and an intermediate "colour" file with reduced resolution, corresponding to the size of a "macropixel" consisting of several pixels, typically four.

In the "black" file, one bit is sufficient for identifying the radiometric or reflectivity value of the pixel (black or not black, i.e. white); by assigning each coloured macropixel to a class, four bits are sufficient for each macropixel, which corresponds to one bit per pixel.

For a number of applications, it is of advantage to have a stored representation which makes it possible to select between two display modes of a map portion:

- a low scale display for which a large area, comparable to that of a full individual paper map, may simultaneously be observed on a screen, for instance with each macropixel having a size of about 200 μm (as compared with 250-300 μm per pixel in most present day display modes);
- a high scale representation, with a high resolution of the alpha-numeric characters and symbols, for better readibility thereof.

(a) In some cases, a complete display with a reduced resolution may be accepted, corresponding to the size of a macropixel of 0.2 x 0.2 mm, the matrix of "black" pixels may be fractionated into squares having an individual size equal to that of one macropixel; in the file, one of the pixels of each square is assigned to a class defined, not by its real value, but by a value calculated from the four pixels (at 22 in Figure 1).

In the "colour" file 20, each macropixel is computed from the four corresponding pixels by an operator using a colour priority table. This table may be defined, for each particular case, by an operator, always on

the basis of the same general rule, namely that priority is given to the most significant colour, namely the color carrying most data. Frequently, the following priorities, in decreasing order, will be used.

- colour used for alpha-numeric characters and overprinting,
- colour assigned to the elements of small area or linear elements,
- other colours, by order of importance.

In a map in which the level curves are black, the following decreasing priority order for the colours may be adopted:

- colour assigned to inscriptions or symbols,
- colour assigned to the road network,
- colour assigned to the hydrographic network,
- colour assigned to the forests,
- background colours.

This step makes it possible to obtain much more satisfactory retrieval than sub-sampling of one colour pixel out of n (n being an integer greater than 1).

(b) An alternative approach will now be given, assuming that the black pixels are not identified during step 1 and "black" is considered as a colour, with the radiometric values for cyan, magenta and yellow lower than specific thresholds. For easier computation the codes p(a) attributed to the colours will be all the more greater as the colour has a greater priority. For instance

a	p
black (text)	8
dark blue (hydrography)	7
red (roads)	6
orange red (level lines)	5
light blue (water sheets)	4
green (vegetation)	3
grey (shades)	2
white (background)	1

More generally, processing can be as follows if <u>b</u> is the code value for black and is attributed to the background colour (i.e. white);

All sets of four pixels having respective code values a_1, a_2, a_3, a_4 are processed for generating a "black" file and a "colour" file.

In the "black" file, each pixel has a value b_i which may be zero (not black) or one (black). Operation is: assuming that b (8 in the above table) is the code value for black:

$i = 1, 4$
$b_i = 0$
except if $a_1 = b$; then, $b_i = 1$.

The "colour" file stores macropixels each having a value a_0; assuming that w designates the lowest priority code value (white in the above table) then the stored value a_0 results from a processing sequence as follows:

$p = 0$
$a_0 = w$
$i = 1, 4$
if $[p(a_i) > p$ AND $a_i = b]$
then $a_0 = a_i$
$p = p(a_i)$

A modification which renders later decompression faster consists in further deciding:

$b_1 = 1$ if $(a_2 = b)$ OR $(a_3 = b)$ OR $(a_4 = b)$

For each set of four pixels, there will be four bits b_1, b_2, b_3, b_4 in the "black" file and one multibit member in the "colour" file (Figure 1A).

6. Final compression uses the fact that, along a scanning line, a same colour may exist over a considerable distance.

Each black file may in particular be compressed by coding the lengths of black and white segments along the scanning direction during digitization, by identifying the first pixel and the number of pixels in the segment before reverting to the black (or out of black).

In practice, this final compression reduces the storage volume to 0.38 bit/pixel in the "black" file for typical maps.

The colour file for each block may be similarly compressed at 26 (Figure 1), by storing the digit indicating the class of each pixel at the beginning of each uniform colour segment, and the number of pixels in the segment.

Because the coloured zones are more numerous and have a larger area than the black zones, in a typical case, the file can be stored in a form which requires 0.25 bit/pixel, namely 1 bit/macropixel. The complete storage corresponds then to 0.63 bit/pixel.

For each block two files 28 are obtained which may be stored in an addressable bulk memory (hard disk for example) containing all the files of the mosaic.

The method may be implemented in a production line whose input member is a conventional scanner. The scanner may be separate from the rest of the line which then receives the files representing the paper maps in three fundamental colours stored on bulk data carriers. The line may be used not only for acquisition but also for retrieval and display by adding an electronic processing board specific to the retrieval functions.

Real time retrieval takes place by a procedure which is the reverse of the preceding one. It will first be described with reference to Figures 2 and 2A in a case where it takes place with a high resolution of 0.1 mm/pixel, in a line having a general construction as shown in Figure 3.

The line of Figure 3 comprises a central computing unit 30 (CPU) having a hard disk unit 32 forming a high capacity memory for storing files 28. The CPU is provided with a display RAM 34 having a storage capacity sufficient to contain at least the number of blocks (of 512 x 512 pixels for instance) required for forming the image on a display screen 36. Referring to Figure 3, RAM 34 may have a capacity of nine blocks 38; that part 40 of the display memory corresponding to the zone to be visualized is indicated by hatching.

The CPU 30 has input peripherals comprising a keyboard 42 and a mouse 44 for designating for example that point to be located in the middle of the screen, by modifying the contents of the screen memory under the control of the computing unit 30 which, if required, transfers new blocks from the disk unit 32 to the RAM 34. In other words, the display RAM 34 is permanently up-dated in response to commands indicating a zone in the mosaic map introduced by an operator.

In addition to block selection, the CPU 30 processes the data read from the disk unit 32 before writing them into the display RAM 34, so that they can be directly used by the display memory. Selection (at 46 in Figure 2) is by the operator. The respective blocks are addressed in the disk unit 32 and the two files of each block are processed in parallel.

For each file, decompression (at 48 in Figure 2) restitutes the black pixels and the colour macropixels. The black blocks are decompressed and brought to the television type scanning (raster scan) format before they are written into the display memory 34. The colour blocks are processed in the same way but, in addition, the macropixels are over-sampled at 50 by duplication, for making available pixels of the same size as the black pixels. Finally, the black pixels are inserted in the corresponding colour blocks. Decompression is made by a specific retrieval electronic board included in the line and which only comes into play during retrieval.

The pixel recovery process in that case is schematized in Figure 2A. The four colour pixels in a set are obtained by the processing loop:

$i = 1, 4$

$d_i = a_0$

if $b_i = 1$, then $d_i = b$.

When a definition corresponding to the size of a macropixel is sufficient (for instance for a small scale display), step 50 is omitted; on the other hand an additional step 52 for processing the "black" file is provided: only those pixels in the "black" file are retained which were computed from radiometric values of a set of four pixels.

In other words, there is sub-sampling (one column out of two and one line out of two). The value of the pixel retained is assigned to a complete macropixel. If the approach schematized in Figure 1A was used for compression, then the processing sequence for a set of four pixels represented by

a_0 (from 1 to 8 for instance) in the colour file,

b_1, b_2, b_3, b_4 in the black file,

may be as follows (Figure 2B).

A macropixel d_0 is reconstructed by a process which results from the rule that the macropixel b_0 is black if one at least of the pixels b_i in the set is black:

$d_0 = a_0$

i (1,4)
if (b_1 = 1), then d_0 = b

If the modified compression mode was used, then the sequence is faster:

d_0 = a_0
if (b_1 = 1), then d_0 = b

The reconstructed block is in all cases transferred to its proper position in the display memory.

The computing unit 30, the hard disk unit 32, the control keyboard 42 and the display screen 36 of the system can be used not only for acquisition but also for retrieval; an additional I.C. board specific to retrieval is simply added. The algorithms for preparing the black pixels for retrieval thereof with a definition equal to that of a macropixel may be made by software implemented without difficulty in any language.

The reduction of data volume to be stored is apparent when a typical example is considered, formed by the acquisition of maps originating from the French National Geographic Institute at scale 1/50000, with a definition of 0.1 mm/pixel. Conventional digitization in three basic colours requires storing 20.10^6 pixels. Coding by classification makes it possible to reach a compression rate of 6. With two files, one black and the other coloured, the compression rate may be doubled without significant loss of visibility. Finally, with a compression by segments, an overall compression rate of about 38 may be obtained: a whole map may be stored with $1.6.10^6$ bytes, instead of 60.10^6 in the case of direct digitization.

Claims

1. A process for acquiring and digitally storing coloured geographical maps, comprising the steps of:
(a) digitizing each of a plurality of mutually adjacent maps by raster scanning for representing each map by a matrix of pixels encoded for representing at least three fundamental colours of each pixel;
(b) classifying the pixels of each of said maps by assigning them to a predetermined number of classes depending on their colour, whereby each of said pixels is defined by a code having a number of bits less than that for step (a);
characterized by the additional steps of:
(c) forming a mosaic of mutually connected maps by re-sampling said maps, in a common reference grid, typically by assigning to each re-sampled pixel the code of the closest pixel obtained by operation (b);
(d) splitting up the mosaic into mutually identical blocks, each having a predetermined number of pixels;
(e) forming a colour file for each pixel by (e1) compressing the pixels into macropixels each consisting of n mutually adjacent pixels (for example n = 4 pixels disposed in a square array) and assigning each macropixel to a single class representative code, then (e2) storing, in each line of macropixels, each segment having constant colour segment in the form of the code of the class of the first macropixel of the segment and the number of macropixels of the segment; and
(f) forming a black-and-white file for each block by storing, for each line in the block, each black segment in the form of the indication of the first black pixel and the number of pixels of the segment.

2. Process according to claim 1, characterized in that, during step (e), each of said macropixels is generated starting from the values of four pixels distributed in a square array.

3. Process according to claim 2, characterized in that, during step (f), the predetermined pixel is substituted in each macropixel with a value obtained from the four pixels used for generating the macropixel, in the black-and-white file.

4. Process according to claim 3, characterized in that said predetermined pixel is given a black value if anyone of the four pixels in the macropixel is black.

5. Process according to any one of claims 1-4, characterized in that during step (b), each of said classes is determined by the algorithm of the migrating means on a three-dimensional histogram of the distribution of the colours in a map or a set of maps.

6. Process according to claim 5 for coding maps having eight colours or less, wherein the number of classes is selected at a value lower than 16.

7. Process according to any one of claims 1-6, further comprising, for retrival and display of a map zone:
(g) displaying the map zone on a screen from said colour file and said black-and-white file by carrying out an expansion consisting of an operation which is dual of (e) and (f) whereby coloured pixels are obtained by oversampling of said macropixels, displaying the pixels of the oversampled colour file and incrustating the black pixels.

8. Process according to claim 4, characterized in that, for low resolution display of a map zone, it comprises carrying out operations dual of steps (e) and (f), decimating the black-and-white file by selecting

only said predetermined pixels; displaying the colour macropixels; and incrustating said predetermined pixels, when black, each in substitution of one coloured macropixel.

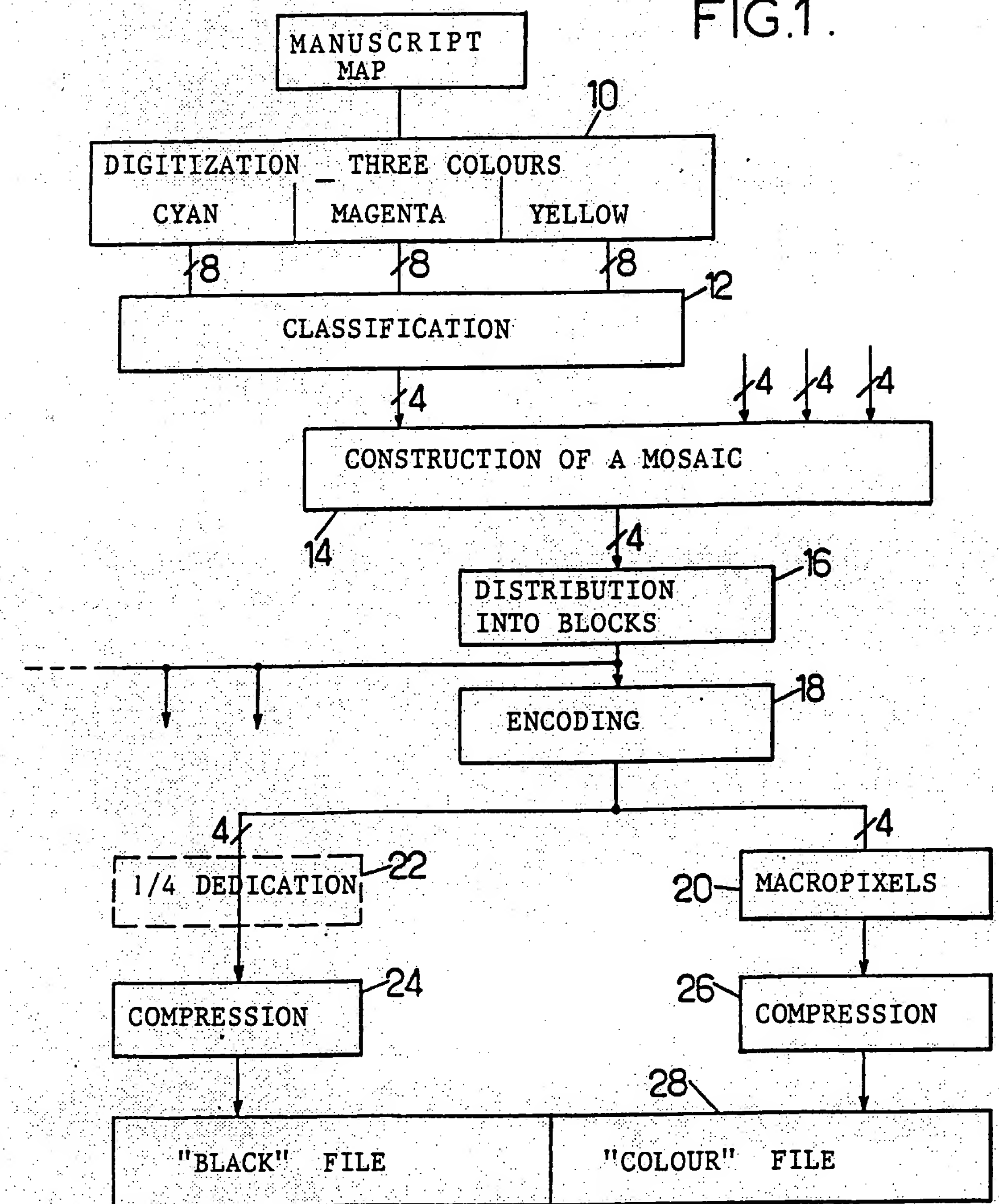
9. Device for acquisition and digital storing of geographical maps, comprising:

- means (10) for raster scanning maps and digitizing them for representing each map as a matrix of pixels each encoded by at least three digital numbers each representing a fundamental colour;
- means (12) for classifying the pixels by distributing them between a predetermined number of classes each defined by a signature, according to a maximum likelihood criterium, each class being defined by a code having a number of bits lower than that necessary for encoding the individual pixels;

characterized in that it further comprises:

- means (14) for generating a mosaic of mutually connected maps by resampling in a common reference grid;
- means (16) for fractionating said mosaic into mutually adjacent identical blocks each having a predetermined number of pixels;
- means (20-28) for generating a colour file of each block by grouping said pixels into macropixels each having n mutually adjacent pixels and dedicating a single class representation code to each macropixel then storing, for each line of macropixels, each segment having a constant colour as the code of the class of the first macropixel and the number of macropixels of the segment and for generating a black-and-white file of each block by storing, for each line, each black segment as the indication of the first black pixel and the number of pixels of the segment; and
- means for writing said files in a mass memory (32) having means for addressing said blocks.

FIG.1.


MANUSCRIPT MAP
10
DIGITIZATION _ THREE COLOURS
CYAN
MAGENTA
YELLOW
8
8
8
12
CLASSIFICATION
4
4
4
4
CONSTRUCTION OF A MOSAIC
14
4
16
DISTRIBUTION INTO BLOCKS
18
ENCODING
4
4
22
1/4 DEDICATION
20
MACROPIXELS
24
COMPRESSION
26
COMPRESSION
28
"BLACK" FILE
"COLOUR" FILE

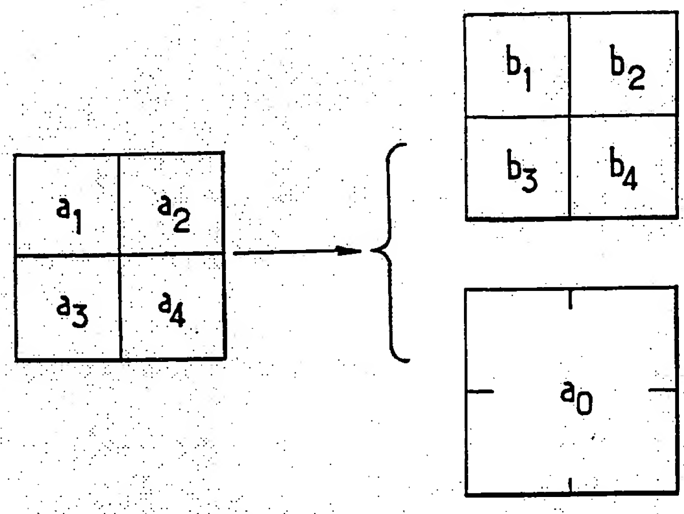


FIG.1a.

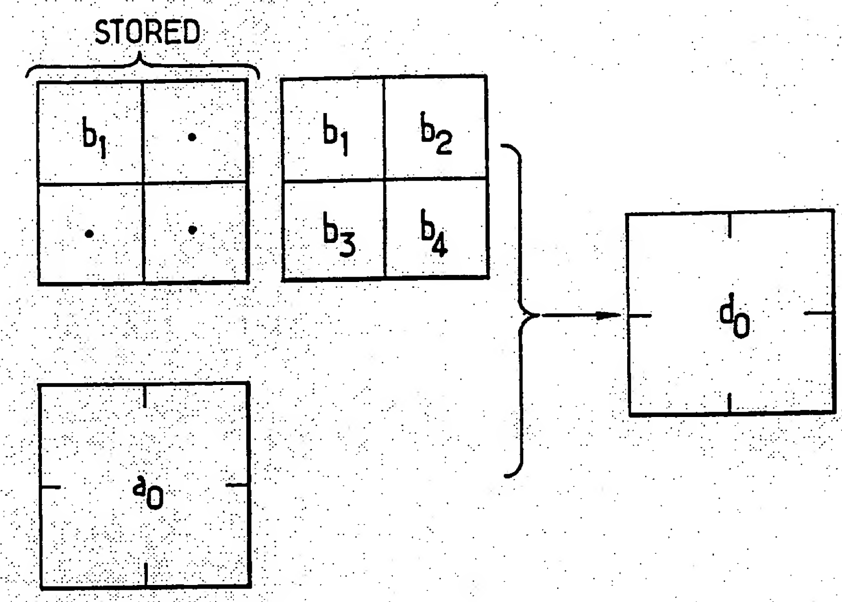


FIG.2B

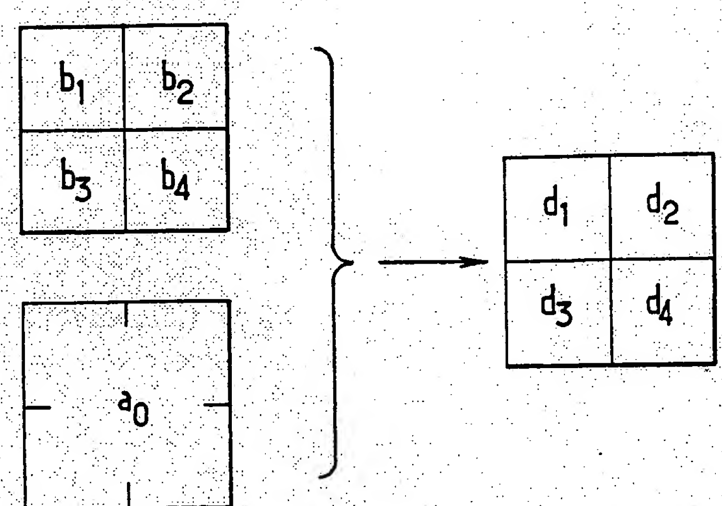


FIG.2A.

FIG.2.

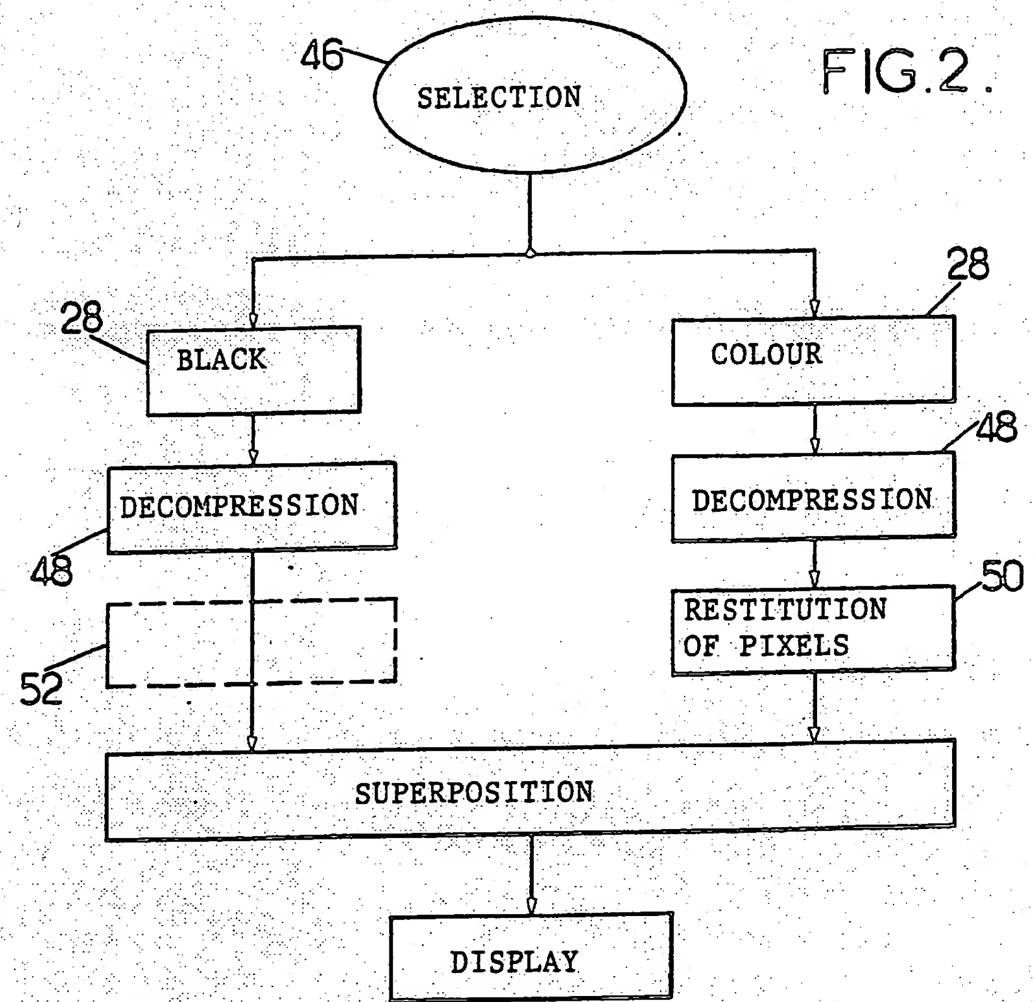
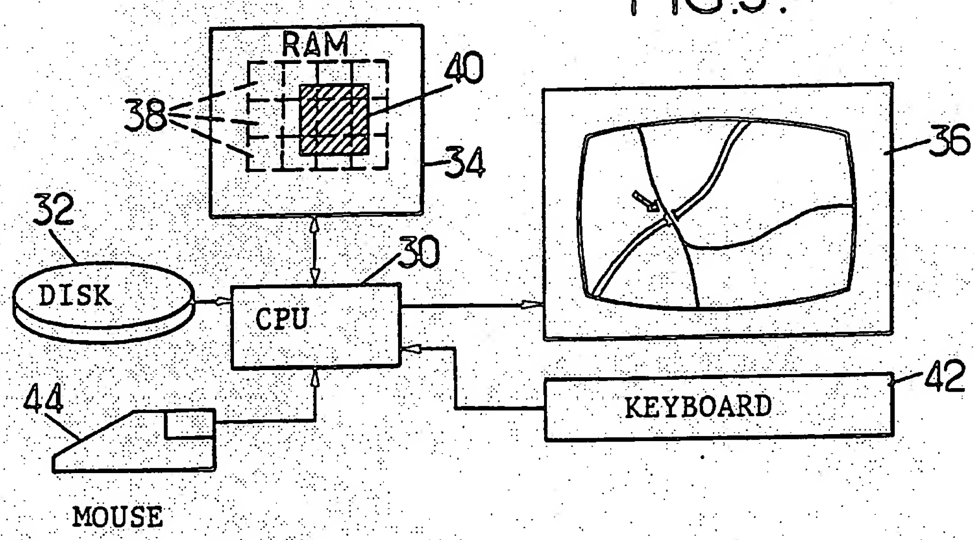

46
SELECTION
28
BLACK
28
COLOUR
48
DECOMPRESSION
48
DECOMPRESSION
52
50
RESTITUTION OF PIXELS
SUPERPOSITION
DISPLAY

FIG.3.


RAM
40
38
34
36
32
DISK
30
CPU
44
42
KEYBOARD
MOUSE

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 40 0663

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,A	PROCEEDINGS OF THE SID. vol. 14, no. 1, 1973, LOS ANGELES US pages 18 - 25; P.J.MIN: "Computer-aided mapping technology for geographic data base" * page 18, column 2 - page 19; figures 5.1-5.3 * * page 24, column 1, last paragraph *	1, 9	G06F15/62 H04N1/46
D,A	PROCEEDINGS OF SPIE, Applications of Artificial Intelligence VI, Orlando,Fla,US, Apr 4-6, 1988, vol. 937, 1988, SPIE, WASHINGTON, US pages 402 - 410; R.L.STANFORD et al.: "The application of knowledge base and digital image analysis techniques to automated map interpretation" * paragraph 3; figure 5 *	1, 9	
A	US-A-4301469 (MODEEN ET AL.) * the whole document *	1, 9	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 MAY 1990	PFITZINGER E.E.

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,A	R.O.DUDA et al.: "Pattern classification and scene analysis" pages 10-43, chapitre 2, 1973, J.WILEY & Sons, New-York, US * pages 17 - 22 *	1, 9	

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